Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

cop

LIBRARY
BUREAU OF AGRICULTURAL ECONOMICS
SEP 22 1933
U. S. DEPARTMENT OF AGRICULTURE

CIRCULAR No. 274 JULY, 1933
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C.

COMPARISON OF A TRENCH SILO WITH AN UPRIGHT SILO

By J. R. Dawson, *senior dairy husbandman*, and A. G. Van Horn,[1] *agent in dairying, Division of Dairy Cattle Breeding, Feeding, and Management, Bureau of Dairy Industry*

CONTENTS

	Page
Introduction	1
Preliminary trial of the trench silo	2
The trench silo	2
The upright silo	3
Experimental methods	5
Comparative efficiency of the trench silo and the upright silo	7
Cost of various operations incident to filling the silos and removing the silage	11
Cost per ton of edible silage obtained from each silo	13
Summary and conclusions	14

INTRODUCTION

The trench silo, especially when used as an emergency measure, has been much recommended in recent years. One of the principal advantages claimed for it is that skilled labor is not required for its construction; hence renters and small farmers can readily construct such a silo with little or no cash outlay and without the assistance of outside labor. In addition, the trench silo is recommended as frostproof, windproof, and fireproof; it can be filled easily, and water can be added readily to the silage during the process; the silage is easily removed from it; neither expensive machinery nor a great deal of power are required for filling it; finally, it is especially adapted to the use of silage harvesters or machines that cut up the crop in the field as it is harvested.

Among the principal disadvantages cited against the trench silo are the facts that more silage tends to spoil in it than in an upright silo; that the feeder is exposed to the weather while removing the silage for feeding; that the edges of the trench must be smoothed up every fall; that it is unsightly and mars the appearance of the barnyard when located near the barn; that the trench is difficult to fill in when it is to be abandoned, and that it is not suitable for locations where the ground water may at times stand near the surface.

In order to obtain some definite, comparable information about the relative merits of the trench and the upright silo, an experiment was started at the United States Dairy Experiment Station at Woodward, Okla., in the fall of 1929. The principal object of

---

[1] Mr. Van Horn is superintendent of the U.S. Dairy Experiment Station at Woodward, Okla., and the work at this station is carried on in cooperation with the Oklahoma Agricultural and Mechanical College, Stillwater, Okla.

174230°—33

this experiment was to compare the efficiency of the two types of silos in preserving silage, at the same time ascertaining the relative cost of filling them and of removing the silage from them.

Information obtained from the experimental work for two seasons, 1929–30 and 1930–31, is presented in this circular. There is included a description incident to filling and emptying the silos, and the costs of construction.

Since the use of the trench silo has increased rapidly in recent years, especially in regions where droughts are prevalent, this information should be of immediate practical value. The trench silo constructed at the Woodward, Okla., station was, so far as is known, the first one in that locality. It is estimated that between 250 and 500 trench silos have since been dug as a result of this demonstration. More than 100 are in use in Canadian County, Okla., and 20 were filled in Woodward County in 1931.

PRELIMINARY TRIAL OF THE TRENCH SILO

An upright silo built in 1921 and a trench silo dug in 1927 were available at the station for the experiment. The trench silo had been dug chiefly as an emergency measure in order to demonstrate its practicability in saving drought-stricken crops. It was filled in the fall of 1927 with approximately 70 tons of Sunrise kafir, run through a silage cutter. The silage was thoroughly packed by driving cattle through the trench several times while it was being filled, and by driving a tractor over the silage several times after the trench was full. Some water was added, but no record was kept of the quantity of water or other material placed in the trench nor of the quantity of silage removed from it. After the trench was full the surface of the silage was covered with a 12-inch layer of soil, a team and a Fresno scraper being used for the purpose.

The silage was fed out in 1928, during April, May, and June. The trench was opened at one end, a strip of the soil covering 4 or 5 feet wide being removed at a time as feeding progressed. The silage under each strip of soil was fed down to the bottom of the trench before another strip was uncovered. The silage proved to be of excellent quality, except for a moldy layer on top, which averaged about 10 inches in thickness, and a small quantity of moldy silage along the walls of the trench. There was practically no loss in the silage exposed during the time of feeding, except that caused by rain. During May, heavy rains made it necessary to dip the water from the trench on two occasions. This water was merely the accumulation of rain that fell within the silo walls, as no water from the outside drained into the trench.

As this preliminary trial had shown that the trench silo was a practicable means of preserving silage crops, the trench was enlarged to its present capacity in 1928, but it was not filled that year for lack of silage material.

THE TRENCH SILO

The soil in which the trench silo was dug is a sandy loam, but the subsoil is hard and contains considerable amounts of gypsum. A hard layer of gypsum was encountered at a depth of 5 feet, and it was necessary to blast in order to break through. Two men with a team, a plow, and a Fresno scraper were required in excavating the trench.

As originally dug, in 1927, the trench was 71 feet long, 6 feet 9 inches deep, and 14 feet wide at the ground level, and 10 feet wide at the bottom. At each end of the trench the bottom sloped upward, forming a gradual incline to the ground level. The capacity of the trench was approximately 4,460 cubic feet, and the cost of constructing it was $100, practically all of which was expended for labor. During the summer of 1928 the trench was lengthened to 112 feet at a cost of $39. This increased the volume to 7,809 cubic feet, with an estimated capacity of 107 tons of silage (figs. 1 and 2).

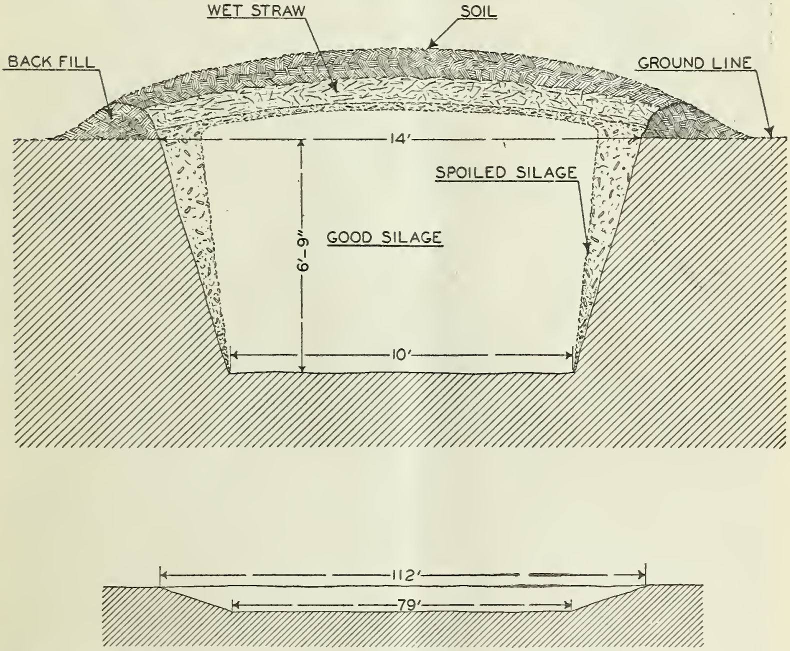

FIGURE 1.—Cross section and longitudinal section of the trench silo showing the dimensions, the covering of wet straw and soil, and the location of most of the spoiled silage.

The trench silo was approximately 60 feet from the wing of the barn in which young stock and bulls were kept and approximately 230 feet from the stanchion barn in which the milk cows were fed (fig. 3).

THE UPRIGHT SILO

The upright silo used in this experimental work is of tile-block construction and is 14 feet in diameter and 22 feet deep. It is of the semipit type, having 11 feet of its depth below and 11 feet above the ground level. Originally the pit extended 16 feet below the ground level, but because of water seepage it was necessary later to fill in 5 feet. As originally built in 1921, the total cost of construction was $450.

The upright silo is located at the west end (fig. 3) of a covered passageway connecting two main wings of the dairy barn, approximately 30 feet from the part of the barn in which young stock and bulls are kept and 150 feet from the wing in which the milking cows are housed. It is connected with the passageway in such a manner that the feeder is not exposed to the weather. This silo has no roof, but is considered first-class in every other way.

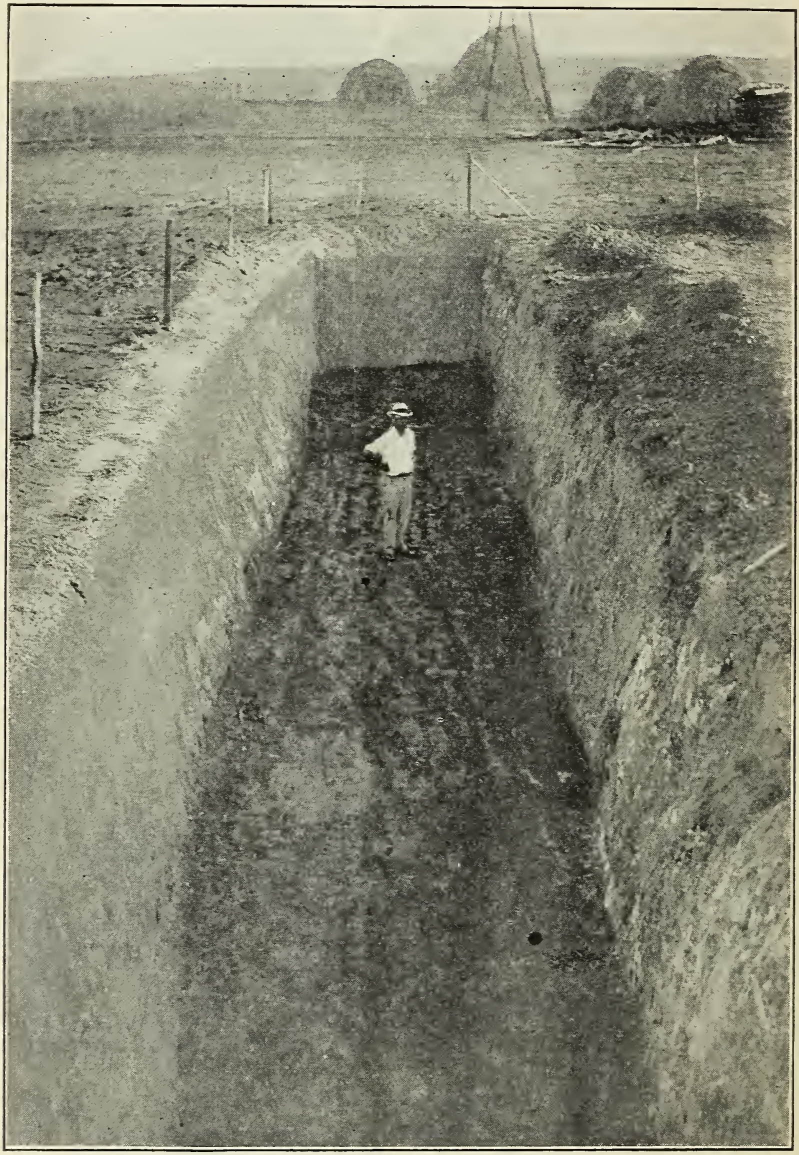

FIGURE 2.—The trench silo used in the experiment.

EXPERIMENTAL METHODS

Records of the quantities of green material placed in each silo, and of water added to the silage, were kept for the two seasons 1929–30 and 1930–31. A standard silage cutter equipped with a blower and distributor pipe was used in filling the silos both seasons. The knives of the cutter were kept sharp and the silage was cut fine. The green material was weighed before it was run through the cutter.

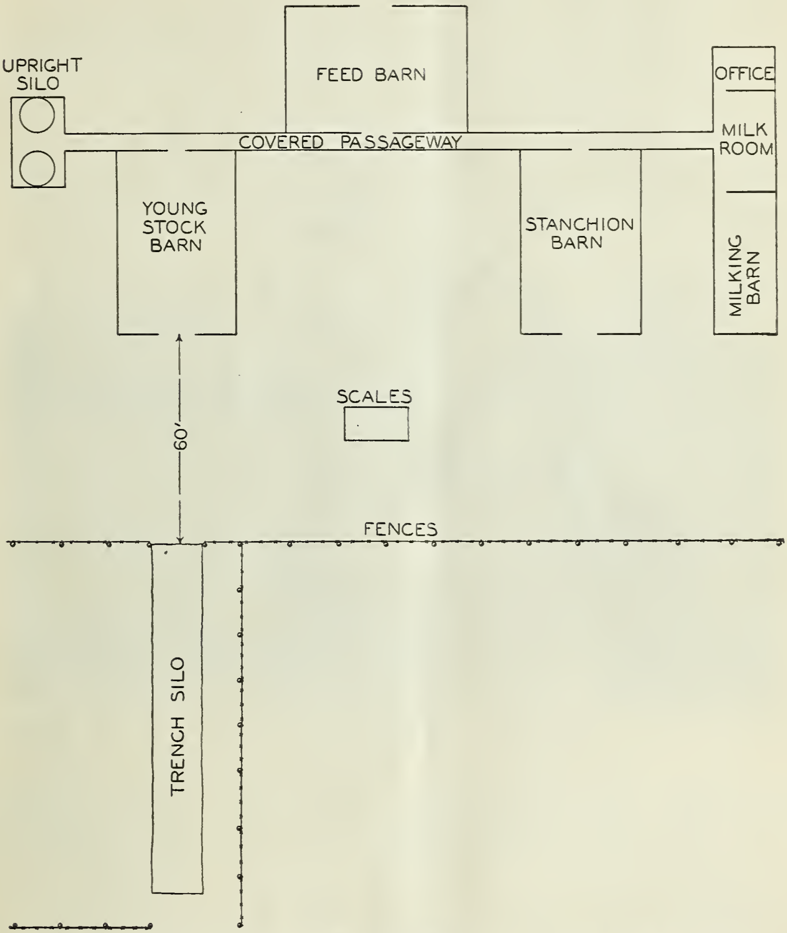

FIGURE 3.—Location of the silos and barns at the Woodward, Okla., station.

The water was added through the blower of the silage cutter and the amount was measured with a water meter.

In filling the trench silo the blower pipe was raised to a height of 22 feet above the ground where it was held in position by two standing poles bolted together at the top and guyed in two directions by wire cables (fig. 4). This was an effective arrangement for distributing the silage in the trench. The cutter was set at three different positions along the side of the trench during the filling operation, and at each position the trench was filled up to the ground level. Three men tramped and distributed the silage in the trench as it was being filled. In addition, a tractor was run back and forth over the silage after the trench was full. The silage was then covered with partly rotted wheat straw, which was thoroughly soaked with water and tramped, and then covered with a layer of soil 12 to 16 inches deep (fig. 1). A team of horses and a small Fresno scraper were used in placing the soil over the straw. Time and cost records for the various operations were kept.

The upright silo was filled in the usual manner of filling silos of this type, using the same cutter and blower used in filling the trench silo. Water was added in the same manner as in the trench silo, and the silage was thoroughly tramped. When the silo was full a layer of old wheat straw about 12 inches thick was placed on top of the silage. This was thoroughly soaked with water and tramped.

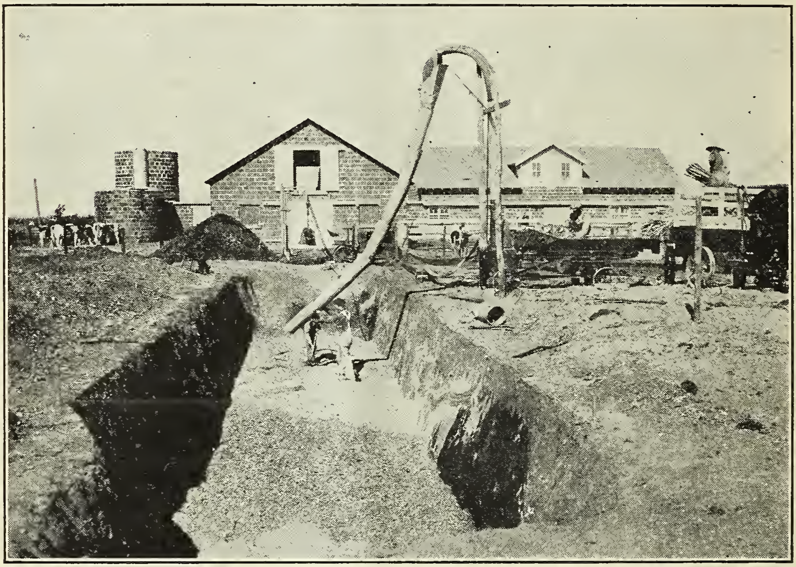

FIGURE 4.—Filling the trench silo. Note how the blower pipe is held in the raised position. The upright silo used in the experiment is shown in the background.

When the trench silo was opened for feeding, the soil-and-straw covering was removed in strips 5 to 6 feet wide, across the trench, the first opening being made at the south end. In January 1930, when the first strip was removed, the covering was frozen and some difficulty was experienced in removing it. However, when the second strip was removed, the soil had thawed so that a team and scraper could be used. There was no difficulty caused by freezing in removing the soil covering during the 1930–31 season.

After a strip of covering was removed the silage underneath was fed out until the bottom of the trench was reached, leaving a perpendicular wall of exposed silage. The exposed silage did not mold except in warm weather or after a rain, although it had a tendency to dry out. The silage was fed out at the rate of approximately 1,800 pounds per day.

In removing the silage from the trench for feeding, a wagon was backed down the incline to the exposed layer and the silage was thrown on the wagon with a silage fork. The loaded wagon was driven to the platform scales where the silage was weighed, and then to the west end of the covered passageway adjacent to the upright silo. The silage was then unloaded on the floor where it was later transferred to the cattle barn by means of an overhead track and silage carrier as needed. Usually enough silage to last 2 days was hauled from the trench in one load. On a few occasions when the incline into the trench was slippery because of rain it was necessary to drive the wagon along the side of the trench for loading.

In feeding from the upright silo, the silage was thrown out of the silo as needed and onto the same spot in the covered passageway at which the silage from the trench was unloaded from the wagon. The silage from the upright silo was weighed on platform scales in the feed barn, by lowering the feed carrier to the scales.

COMPARATIVE EFFICIENCY OF THE TRENCH SILO AND THE UPRIGHT SILO

In 1929 the trench silo was filled with Sunrise kafir and sumac sorgo (cane), and the upright silo was filled with Sunrise kafir only. In 1930 the trench silo was filled with sorgo only while the upright silo was filled with kafir and sorgo.

The method of filling each silo, of covering the silage, and of removing it to the barn was essentially the same in both seasons. Table 1 shows the kinds of crops placed in each silo, the dates of filling, and the dates on which the silage was removed from each.

Table 1.—*Kind and amount of crops placed in the trench silo and upright silo in each season, the dates of filling the silos, and the periods of feeding the silage*

Season and type of silo	Dates of filling	Material ensiled		Period of feeding silage
		Sunrise kafir	Sumac sorgo	
		Tons	*Tons*	
1929–30:				
Trench	Sept. 25, 26, 28, and Oct. 1.	79.28	42.38	Jan. 24 to June 10, 1930.
Upright	Sept. 24	44.47		Nov. 9, 1929, to Jan. 24, 1930.
1930–31:				
Trench	Oct. 1, 2, 3		111.45	Dec. 13, 1930, to May 28, 1931, and Sept. 19, 1931, to Oct. 5, 1931.
Upright	Sept. 29	13.25	27.48	Oct. 3 to Dec. 15, 1930.

Since each silo was filled one year with a mixture of kafir and sorgo but not in the same year nor in the same proportion, and since the upright silo was filled with kafir alone in 1929 and the trench was filled with sorgo alone in 1930, comparable data for each crop in both silos are not available. However, Sunrise kafir and sumac sorgo are similar crops and much the same in chemical composition. Therefore, it is believed that the results are applicable to either or both crops. It was observed, however, that in both silos the sorgo silage kept a little better than the kafir silage.

Any advantage from less spoilage due to colder weather was in favor of the upright silo, as all the silage in this silo was fed out during cool weather. During the 1929–30 season the silage in the upright silo was fed out from November 9 to January 24, while that in the trench silo was fed out from January 24 to June 10. In the 1930–31 season the upright silo was opened on October 3 and the feeding from this silo continued until December 15. The trench silo was opened on December 13 and the feeding continued until May 28; the remainder of the silage was not fed out until that fall, from September 19 to October 5. The fact that no silage was removed from the trench during the entire summer, and that, therefore one end was exposed, caused greater spoilage than if the silage had been fed out continuously without a break. This will be referred to later. In 1929–30, 73 days were required to feed out the silage from the upright silo and in 1930–31, 76 days were required. In 1929–30 it required 137 days to feed the silage from the trench silo, while in the following year a total of 182 days (in two periods) was required.

Another probable advantage in favor of the upright silo was the fact that, in both seasons, feeding from the upright silo began within a few days after the silo was filled. In the first season, the upright silo was opened 15 days after it was filled, while in 1930–31 the time was only 4 days. In the trench silo, 116 and 71 days respectively, for the two seasons, elapsed between filling and opening.

Table 2 shows the amount of green material and water placed in each silo in both seasons, and the amount of edible and spoiled silage removed.

Table 2.—*Total amount of crop material and water placed in the trench silo and in the upright silo each season, and the amount and percentage of this material recovered as spoiled and edible silage*

Season and type of silo	Material placed in silo				Silage removed from silo			Percentage of total ensiled material recovered		Volume of silage when packed	Weight of silage per cubic foot
	Kafir (green weight)	Sorgo (green weight)	Water	Total	Edible silage	Spoiled silage	Total	As spoiled and edible silage	As edible silage		
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Percent*	*Percent*	*Cubic feet*	*Pounds*
1929–30:											
Trench	79.28	42.38	8.02	129.68	104.92	11.96	116.88	90.12	80.91	7,809.8	29.9
Upright	44.47	------	5.48	49.95	42.53	4.58	47.11	94.32	85.15	2,693.9	34.9
1930–31:											
Trench	------	111.45	14.40	125.85	94.27	11.65	105.92	84.17	74.91	7,231.1	29.3
Upright	13.25	27.48	5.13	45.86	41.54	1.77	43.31	94.44	90.58	2,539.9	34.1
Average for 2 seasons:											
Trench	------	------	11.21	127.76	99.59	11.81	111.40	87.15	77.91	7,520.5	29.6
Upright	------	------	5.31	47.91	42.04	3.18	45.22	94.38	87.87	2,616.9	34.5

In the 1929–30 season all water added to the green material ensiled was added to the kafir, since the kafir was drier than the sorgo and experience had shown that it required more water than did sorgo. The water was added at the rate of 1 ton to 9.7 tons of kafir for the trench silo, and 1 ton to 8 tons of kafir for the upright silo.

In the 1930–31 season water was added at the rate of 1 ton to 8 tons of green material (sorgo) ensiled in the trench silo, and at about the same rate to the green material (kafir and sorgo) ensiled in the upright silo.

The lower rate at which water was added to the trench silo the first season apparently had no effect on the quality of the silage, as will be pointed out later. The moisture content of the material as placed in the silos was not determined, but samples of both the kafir and sorgo silage taken from each silo during both seasons showed an average moisture content of 61.7 percent on an air-dry basis. There was no significant variation in any of the samples.

The total weight of the material removed from the trench silo the first season was 9.9 percent less than the total weight of the material put into the trench. In addition, 9.2 percent of the material put into the trench was removed as spoiled silage, making a total loss of 19.1 percent. The silage removed from the upright silo the first season was 5.7 percent less than the amount put in, and 9.2 percent of the material put in was removed as spoiled silage, making a total loss of 14.9 percent.

In the second season 15.8 percent less material was removed from the trench than was put in, and the spoilage was about the same as that for the previous season, making a total loss of approximately 25 percent. This loss is 6 percent greater than that for the previous season and, as has been explained, is probably due to the fact that feeding from the trench silo was discontinued in the spring and not resumed till fall. The loss from the upright silo was about 5.6 percent in material or moisture and 3.9 percent in spoiled silage, a total loss of 9.4 percent. This is 5.5 percent less than for the previous year.

Shaw [2] working on corn silage found an average loss of 10 percent in dry matter, due largely to fermentation of the carbohydrates and to carrying away of the soluble material by the juice.

The average results of the two seasons' trials show that 77.91 percent by weight of the total material ensiled in the trench silo and 87.87 percent of the material ensiled in the upright silo, was recovered as edible silage. This is a difference of about 10 percent in favor of the upright silo.

In an experiment with a trench silo at the Univeristy of Nebraska [3] 114.84 tons of corn was placed in the silo together with 8.66 tons of water, and 99.26 tons of good silage and 7.19 tons of spoiled silage was removed. Of the material ensiled, 80.4 percent was recovered as good silage. This is a somewhat higher percentage of recovery than was obtained from the trench silo in the Woodward experiment.

The essential data from the Nebraska experiment are as follows:

Silage put in silo	tons	114.84
Water added	do	8.66
Total material placed in silo	do	123.50
Good silage removed from silo	do	99.26
Waste silage removed from silo	do	7.19
Volume of total silage when packed	cubic feet	4,806.9
Weight per cubic foot of silage taken out	pounds	44.29
Average moisture content of silage put in	percent	72.9
Average moisture content of silage taken out	do	72.7

---

[2] SHAW, R. H., WRIGHT, P. A., and DEYSHER, E. F. NITROGEN AND OTHER LOSSES DURING THE ENSILING OF CORN. U.S. Dept. Agr. Bul. 953: 5–15. 1921.

[3] WOOD, I. D., and LEWIS, E. B. THE TRENCH SILO IN NEBRASKA. Nebr. Agr. Col. Ext. Circ. 713, 16 p., illus. 1931.

In the preliminary trial with the trench silo at Woodward in 1927, a layer of moldy silage averaging 10 inches thick was found on the top. In that year the covering consisted of soil only, with no straw. Only a small amount of moldy silage was found along the walls of the trench. In the 1929–30 and 1930–31 trials, however, this condition was reversed, that is, most of the spoiled silage was found along the walls and the moldy layer on top was less than 2 inches thick (fig 1). In 1927 the trench was filled immediately after it was dug and the walls did not have time to dry out and therefore absorbed but little moisture from the silage. When the trench was filled in 1929 and 1930, however, the side walls were very dry and may have absorbed sufficient moisture from the silage to cause that along the walls to spoil. However, in the Nebraska experiment[4] one side of the trench was thoroughly soaked before filling, while the other side was not. The soaking of the one side apparently had no effect on the spoiling of the silage.

It is shown in table 2 that silage from the upright silo weighed, on an average, 4.9 pounds more per cubic foot than did silage from the trench silo. It was expected that the silage in the upright silo would weigh considerably more in proportion because of its greater depth. However, the material in both silos was well packed and the 12 to 16 inches of soil covering the silage in the trench silo exerted considerable pressure. Then, too, the trench silo was not opened as soon after filling as was the upright silo and the silage had longer to settle. As previously pointed out, the moisture content of the silage from both silos for both years averaged 61.7 percent on an air-dry basis, with but little variation. In the Nebraska experiment[4] the average moisture content of the corn silage from the trench silo was 72.7 percent, and the average weight per cubic foot was 44.29 pounds. This is almost 15 pounds more per cubic foot than the weight of the silage in the Woodward trench. Undoubtedly, the silage in the Nebraska trench was packed more than that in the Woodward trench, as the Nebraska report states that "the trips of the tractor the length of the trench averaged one per ton of ensilage." At the Woodward station the trench was filled from the bottom to the ground level in three sections. Three men tramped. When the trench was full a tractor was run back and forth over the silage several times. On the other hand, the Nebraska trench was covered only with a layer of wet hay and straw, while the Woodward trench was covered with soil in addition to wet straw. This would tend to pack the silage more.

The Woodward trench was filled with kafir and sorgo the first season and with sorgo alone the second season. The Nebraska trench was filled with corn. Investigations at the Missouri Agricultural Experiment Station[5] show that in upright silos at a depth of 6 to 10 feet a cubic foot of corn silage averages 36.6 pounds in weight while a cubic foot of kafir silage averages 34.6 pounds in weight. The figures for kafir, as shown in table 3, are uniformly lower than the average for corn at all depths.

---

[4] WOOD, I. D., and LEWIS, E. B. Op. cit.

[5] ECKLES, C. H., REED, O. E., and FITCH, J. B. CAPACITIES OF SILOS AND WEIGHTS OF SILAGE. Missouri Agr. Expt. Sta. Bul. 164, 24 p., illus. 1919.

TABLE 3.—*Relative weights of corn, sorghum, and kafir silage at different depths, in upright silos*[1]

Kind of silage	Average weight per cubic foot of silage at a depth of—				
	6 to 10 feet	11 to 15 feet	16 to 20 feet	21 to 25 feet	26 to 30 feet
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Corn	36.6	39.2	40.6	41.6	42.2
Sorghum	30.4	34.4	40.8	42.0	44.0
Kafir	34.6	34.7	36.6	38.0	39.6

[1] From Missouri Agr. Expt. Sta. Bul. 164. (See footnote 5, p. 10.)

COST OF VARIOUS OPERATIONS INCIDENT TO FILLING THE SILOS AND REMOVING THE SILAGE

Such operations as harvesting the material, hauling it to the cutter, and unloading it and feeding it to the cutter were not affected by the type of silo and, therefore, have not been included in considering the comparative costs of filling the two silos and removing the silage from them. Nor would it be desirable to include the weighing and feeding of the silage, or any other operation not affected by the type of silo. However, such operations as setting up and taking down the cutter, distributing and packing the silage, covering and uncovering the silage, and removing the silage from the silo were materially affected by the difference in the type of silo. These operations, together with the number of hours of man labor, team work, and tractor work required for each, and also their costs, are shown in table 4.

TABLE 4.—*Labor and power requirements and costs of various operations, incident to filling the trench and upright silos and removing the silage, for the two seasons' experiment*

Operations, kind and cost of labor and work required for each	1929–30		1930–31		Average for 2 seasons	
	Trench silo	Upright silo	Trench silo	Upright silo	Trench silo	Upright silo
Setting up and taking down cutter:						
Man labor:						
Hours......number	10.00	3.00	10.00	3.00	10.00	3.00
Cost......dollars	4.00	1.20	4.00	1.20	4.00	1.20
Distributing and packing silage:						
Man labor:						
Hours......number	62.00	14.00	54.00	6.00	58.00	10.00
Cost......dollars	24.80	5.60	21.60	2.40	23.20	4.00
Tractor work:						
Hours......number	1.25	----------	1.50	----------	1.38	----------
Cost......dollars	2.19	----------	2.62	----------	2.41	----------
Covering silage:						
Man labor:						
Hours......number	26.00	3.00	24.00	4.00	25.00	3.50
Cost......dollars	10.40	1.20	9.60	1.60	10.00	1.40
Team work:						
Hours......number	8.00	1.00	8.00	----------	8.00	.50
Cost......dollars	2.80	.35	2.80	----------	2.80	.18
Removing covering and waste:						
Man labor:						
Hours......number	43.50	5.00	46.00	4.00	44.75	4.50
Cost......dollars	17.40	2.00	18.40	1.60	17.90	1.80
Team work:						
Hours......number	6.00	----------	7.00	----------	6.50	----------
Cost......dollars	2.10	----------	2.45	----------	2.28	----------

TABLE 4.—*Labor and power requirements and costs, etc.*—Continued

Operations, kind and cost of labor and work required for each	1929–30		1930–31		Average for 2 seasons	
	Trench silo	Upright silo	Trench silo	Upright silo	Trench silo	Upright silo
Removing silage from silo to passageway:						
Man labor:						
Hours..................number..	117.50	25.30	125.40	23.30	121.45	24.30
Cost....................dollars..	47.00	10.12	50.16	9.32	48.58	9.72
Total labor and power required for all operations:						
Hours..................number..	274.25	51.30	275.90	40.30	275.08	45.80
Cost....................dollars..	110.69	20.47	111.63	16.12	111.16	18.30
Total cost of all operations per ton of edible silage removed.........dollars..	1.06	.48	1.19	.39	1.13	.44

All labor for the various operations listed in table 4 was hired. Wages for men were charged at the rate of 40 cents an hour, and team work was charged at the rate of 35 cents an hour for the team alone, since the driver's wages were charged under man labor. The use of the tractor was charged at the rate of $1.75 an hour, which includes the wages of the operator. These were the rates prevailing in that locality in 1930.

The fact that three settings of the cutter were made in filling the trench silo, and it was necessary to move the poles that supported the blower pipe three times, as compared to only one setting in filling the upright silo, accounts for the greater cost of setting up and taking down the cutter in filling the trench silo.

The labor and cost of distributing and packing the silage was much greater in the case of the trench silo than in the upright silo as is shown by the 2-year average for this operation.

The cost of man labor in removing a ton of edible silage was 50 cents for the trench silo and 23 cents for the upright silo (table 5). Hauling the silage from the trench required 121.5 hours of team work also, but this item is not included in the costs of removal given in this circular because it was not considered equitable to do so. In fact, it is hardly equitable to charge all of the 121.5 hours of man labor to the trench silo for this operation, because under the existing conditions the silage from the trench had to be handled twice in loading and unloading it from the wagon, while the silage from the upright silo was thrown directly into the passageway without extra handling. If the trench silo had been as convenient to the passageway as was the upright silo, hauling with teams would not have been necessary, and it is questionable whether the work of removing the silage to the passageway would then be any more expensive than for the upright silo.

At the Mandan, N.Dak., Dairy Experiment Station of the Bureau of Dairy Industry a trench silo has been in use for several years. It is approximately 10 feet from a feed room adjacent to a pit silo. A winch is so arranged that it can be used to raise the silage from the pit silo and also to draw the silage truck from the trench silo. The cost of removing silage under this arrangement is about the same for the two silos.

COST PER TON OF EDIBLE SILAGE OBTAINED

In each of the two silos the total cost of all operations per ton of edible silage obtained agreed very closely in the two seasons and averaged $1.13 per ton for the trench silo and $0.44 per ton for the upright silo. Table 5 shows the cost of each operation and of all operations per ton of edible silage obtained from each silo each season.

TABLE 5.—*Cost of various operations per ton of edible silage obtained from each silo in two season's trials*

Season and type of silo	Cost per ton of edible silage for the operation of—				Total cost per ton of edible silage
	Setting up and taking down cutter	Distributing and packing silage	Covering silage and removing cover	Removing silage from silo to passageway	
1929–30:					
Trench	$0.04	$0.25	$0.31	$0.45	$1.06
Upright	.03	.13	.08	.24	.48
1930–31:					
Trench	.04	.25	.35	.56	1.20
Upright	.03	.06	.08	.23	.40
Average for 2 seasons:					
Trench	.04	.25	.33	.51	1.13
Upright	.03	.10	.08	.23	.44

The cost per ton of edible silage for the operation of setting up and taking down the cutter averaged 3.81 cents for the trench silo and 2.82 cents for the upright silo. Had the trench silo been shorter but deeper, 2 settings instead of 3 would have been sufficient and this cost would have been reduced in proportion. If a silage harvester, that cuts the material into short lengths in the field, had been used instead of a cutter and blower, this cost would have been practically eliminated for the trench silo. Apparently, a blower and distributor pipe are not the most economical equipment for filling a trench silo.

It is probable that if the entire length of the trench silo had been filled from the bottom to the top at 1 setting of the cutter and not in 3 sections, a tractor could have been employed more advantageously in packing the silage and the cost of this operation reduced.

The average cost per ton of edible silage for covering and removing the cover amounted to about 30 percent of the total handling cost per ton of edible silage in the trench silo and 18 percent in the upright silo. It was necessary to cover and uncover approximately 1,568 square feet of surface for the trench. In the upright silo there was only 154 square feet of surface to cover and uncover. Then too, as the silage was fed from the trench silo in 5-foot strips, it was necessary to remove the covering in similar strips. Twenty-two of these sections had to be removed at as many different times, and this added to the cost.

Experience with the trench silo at the Mandan, N.Dak., station has shown that a top layer of silage approximately 1 foot thick spoils when straw only is used for a covering. In the Nebraska experiment,[6] a top layer of silage varying from 4 inches thick in the center to 18 inches thick at the edges, spoiled when straw was used to cover the trench. A top layer of silage less than 2 inches thick spoiled at the Woodward station when soil was placed on top of the straw covering. Assuming that the soil covering in addition to the straw covering resulted in the saving of a 10-inch layer of silage, the saving would amount to approximately 17 tons. If the silage were valued at $3 per ton, the saving would amount to $51. The total cost of covering the trench and removing the covering was only $32.98. The use of soil in addition to straw appears to be desirable.

If the cost per ton of removing the silage had been the same for the trench as for the upright silo, the total cost of handling the silage would have been 85 cents per ton of edible silage in the trench, or approximately double the total cost per ton for the upright silo.

SUMMARY AND CONCLUSIONS

The cost of constructing the Woodward trench silo was $1.78 per 100 cubic feet of capacity, practically all of which was for team and man labor. The original cost of material and construction of the upright silo when built in 1921 was $10.82 per 100 cubic feet of volume. The construction cost of the trench silo per unit of space was about one sixth that of the upright silo. The upkeep on the trench silo, because of the hard ground which prevents caving of the sides, has been practically negligible during the 4 years since it was constructed.

The upright silo is markedly superior to the trench in preserving silage. On the basis of the average losses during the 2 years' experiment it may be expected that 78 out of every 100 tons of material placed in the trench silo can be recovered as edible silage, and 9.2 tons of the 22-ton loss will be the result of spoilage. In the upright silo 88 tons out of every 100 tons of material ensiled can be recovered as edible silage, and 6.5 tons of the 12-ton loss will be the result of spoilage. The figures for the trench used in the experiment are somewhat high because the silage was not all fed out before the summer in the second year. If only the first year's results with the trench silo are used, then 81 out of every 100 tons of material ensiled will be recovered as edible silage, and 9.2 tons of the 19-ton loss will be the result of spoilage. At $3 a ton the silage lost in the trench silo (first year's results) would be worth $57 and that lost in the upright silo (average two seasons) would be worth $36.

The spoiled silage in the trench silo was largely along the walls of the trench. The quality of edible silage from both silos was excellent.

The average weight of a cubic foot of silage under the conditions of the experiment was 29.6 pounds for the trench silo and 34.5 pounds for the upright silo. The moisture content of the silage was practically the same for both silos. The weight per cubic foot of silage from the trench silo was considerably lower than similar weights for corn and kafir silage at other experiment stations.

---

[6] WOOD, I. D., and LEWIS, E. B. Op. cit.

In this experiment, the total cost of placing the crops in the silos (from the cutter) and removing the silage from the silos was $1.13 per ton of edible silage for the trench and $0.44 for the upright silo. It is pointed out, however, that the location of the trench and the methods and equipment employed will materially affect these costs. The handicap of the increased labor item for the trench silo will vary with the individual farm in accordance with the amount of labor available at the season of the year when these various operations are to be conducted.

The cost of covering the silage and removing the cover from the trench is excessive, and is probably the most significant item of expense in trench-silo operation.

A layer of straw together with 12 to 16 inches of soil as a covering is more efficient in preserving the silage than is straw alone.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	Henry A. Wallace.
Assistant Secretary	Rexford A. Tugwell.
Director of Scientific Work	A. F. Woods.
Director of Extension Work	C. W. Warburton.
Director of Personnel and Business Administration.	W. W. Stockberger.
Director of Information	M. S. Eisenhower.
Solicitor	Seth Thomas.
Bureau of Agricultural Economics	Nils A. Olsen, *Chief.*
Bureau of Agricultural Engineering	S. H. McCrory, *Chief.*
Bureau of Animal Industry	John R. Mohler, *Chief.*
Bureau of Biological Survey	Paul G. Redington, *Chief.*
Bureau of Chemistry and Soils	H. G. Knight, *Chief.*
Office of Cooperative Extension Work	C. B. Smith, *Chief.*
Bureau of Dairy Industry	O. E. Reed, *Chief.*
Bureau of Entomology	C. L. Marlatt, *Chief.*
Office of Experiment Stations	James T. Jardine, *Chief.*
Food and Drug Administration	Walter G. Campbell, *Chief.*
Forest Service	R. Y. Stuart, *Chief.*
Grain Futures Administration	J. W. T. Duvel, *Chief.*
Bureau of Home Economics	Louise Stanley, *Chief.*
Library	Claribel R. Barnett, *Librarian.*
Bureau of Plant Industry	William A. Taylor, *Chief.*
Bureau of Plant Quarantine	Lee A. Strong, *Chief.*
Bureau of Public Roads	Thomas H. MacDonald, *Chief.*
Weather Bureau	Charles F. Marvin, *Chief.*

This bulletin is a contribution from

Bureau of Dairy Industry	O. E. Reed, *Chief.*
Division of Dairy Cattle Breeding, Feeding, and Management.	R. R. Graves, *Principal Specialist in Dairy Cattle Breeding, Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1933

For sale by the Superintendent of Documents, Washington, D.C. - - - - - - - Price 5 cents